HEATH
Schlumberger

SERVO AMPLIFIER CARD

Model EU-900-CB

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HEATH COMPANY
BENTON HARBOR, MICHIGAN 49022
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GENERAL INFORMATION

The several chassis modules and plug-in circuit cards in the Model EU-801 Analog-Digital Designer (ADD) make it a versatile system that is ideally suited for laboratory experiments in basic logic and digital operations, instrumentation, and computation. The ADD is equally well suited for the development and construction of a great variety of complex digital and analog devices, instruments, computer interfacing circuits, etc.

The chassis modules in the Model EU-801 provide the mounting frame, power connections, input/output circuitry, and controls for the plug-in circuit cards. The cards provide the functional circuitry for the operation to be performed, with a unique system of patch-wire interconnection between cards and modules.

TEXT

The text "Digital Electronics For Scientists" by H.V. Malmstadt and C.G. Enke (W.A. Benjamin Inc., Publisher) includes many experiments and applications in digital electronics and instrumentation for which the Heath EU-800 Series equipment is ideally suited. Portions of some of the Manuals in this series are taken from this text with permission of the authors and publisher. These portions are indicated in the Manuals by ☆DES

MODULE INSTALLATION

The most convenient location for any module in the Analog-Digital Designer will depend upon its type, application, and the length of the power connector cable. The Digital Power Module will usually occupy the left-hand position in a 3-module cabinet. The other modules can be transposed, used alone, or connected and operated outside of the cabinet.

To install the module in a 3-module cabinet, slide the module into position from the front of the cabinet as shown below. Push firmly on the module until the spring catch on its chassis snaps onto the catch pin on the base of the cabinet.

Power connections between the modules in the ADD are made with 6-pin connectors and cables, at the rear of each module. Plug the male cable connector from each module except the Digital Power Module into the female chassis connector on the module to its left. The 6-pin cable connectors will transfer power from module to module.

When the installation and interconnection of the modules is complete, they may be secured in the cabinet with the 8-32 thumbscrews on the underside of the cabinet.

CIRCUIT CARD INSTALLATION

Any circuit card can be installed in virtually any card location in any module, except the Digital Power Module, and only the cards necessary for a given function need to be installed. The physical location of a card in the ADD will generally depend on convenience and the desirability of using short patch wires. If a circuit card should require an occasional adjustment, refer to the Adjustment section of the card Manual.

To install a card at a selected location, slide the ends of its circuit board into the front and rear guides in the module; then press the card firmly into place. Be sure the power connectors on the card fit onto the connector pins in the Module.

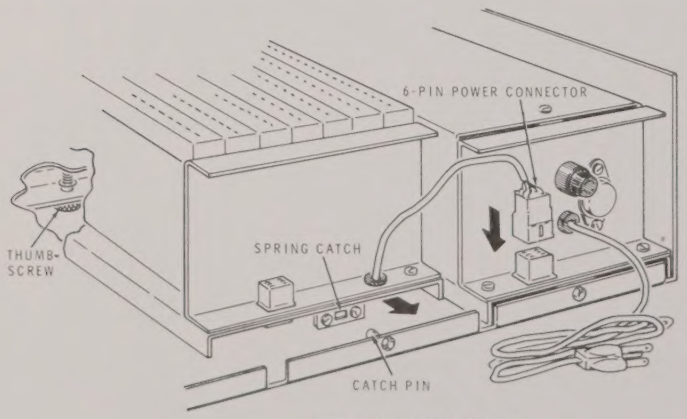
CONNECTIONS

Connections between cards and modules in a Model EU-801 Analog-Digital Designer are made quickly and inexpensively with lengths of standard #22 solid hookup wire. The bare ends of the hookup wires are inserted into the appropriate connectors in the connector guide housing. Components such as resistors and capacitors can also be used between connectors where circuits require their use, providing the component leads are not larger in diameter than #22 gauge. Do not insert more than one wire or component lead in a connector at one time.

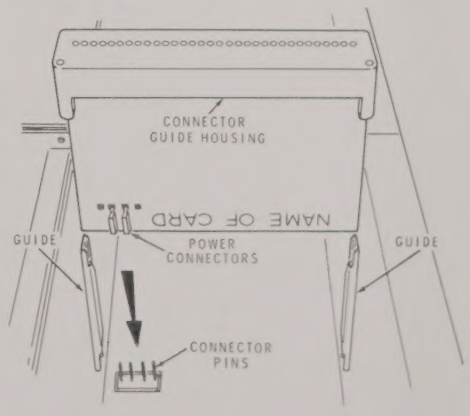
Patch wire may be prepared from lengths of #22 solid hookup wire. Cut the wires to the desired lengths and remove 1/2" of insulation from the ends. Do not use wire that is larger in diameter than #22 gauge (.025 inch).

The face of the connector guide housing is clearly labeled to indicate the circuit point for each connector. Groups of connectors tied to a common circuit point are indicated on the card label by joined lines. When more than one connection must be made to a single point, use one of the Multiple Connector Cards that are provided in the Model EU-801 ADD.

CAUTION: Transistors and integrated circuits can be damaged by excess voltage. The input signal to any digital circuit card must be within the range of 0 to +5 volts unless the card Manual indicates otherwise.



MODULE INSTALLATION IN EU-800R SERIES CABINET



CARD INSTALLATION IN AN EU-801 SERIES MODULE

SERVO AMPLIFIER CARD

Model EU-900-CB

TABLE OF CONTENTS

Introduction 2

Specifications 3

Circuit Considerations 4

Operation and Applications 6

Adjustment 8

Circuit Description 9

In Case of Difficulty 11
- General Troubleshooting 11
- Troubleshooting Chart 12
- Circuit Board Repair 13

Replacement Parts List 14

Parts Pictorial. . .(fold-out from page) 15

Schematic. . .(fold-out from page) 15

X-Ray View. . .(fold-out from page) 16

INTRODUCTION

The EU-900-CB Servo Amplifier Card is a plug-in subsystem of the EU-205-11 potentiometric strip chart recorder, and when used in the recorder it performs many of the basic functions required in any servo system. The unique design of the EU-900-CB circuit card makes it also generally applicable for developing and building many types of instrument servo systems. The card can be plugged directly into the widely-used Analog-Digital Designer (ADD), where it is easily interconnected with other functional circuit cards to provide specialized scientific instrumentation.

All circuits on the card, except the output stage and the input to the reference regulator, can be automatically powered by the regulated voltages from the ADD. The output power amplifier must be powered by some external supply (such as two Model EU-41A supplies) that provides ±15 to ±20V.@ approximately 500 mA maximum.

The circuits on the servo-amplifier card function as follows: (1) a solid state FET (field-effect transistor) chopper is used to alternately compare an input signal voltage to a reference voltage, one of which is controlled in magnitude by a feedback circuit; (2) the difference voltage between input signal and reference is amplified by a 2-stage low noise FET amplifier; (3) the amplified chopped signal is demodulated and filtered to provide a dc signal whose polarity is determined by whether reference or input signal is the larger; (4) the filtered dc signal is further amplified by an output driver amplifier consisting of an integrated circuit operational amplifier (OA) whose output is fed to a bidirectional PNP-NPN power amplifier that provides sufficient current output to operate small dc instrument motors, relays, and similar loads; (5) an OA damping circuit provides a lead angle for the reference signal so as to prevent overshoot or oscillation as the servo comes to balance; (6) a temperature-compensated zener reference voltage regulator is included on the card to provide a highly stable voltage for operation of a feedback element.

All of the circuits on the card can be patch wired so the unit becomes a complete servo subsystem as used in the 200-series recorders. However, certain selected circuits on the card can also be used separately with circuits on other cards as required for specific applications.

SPECIFICATIONS

GENERAL

Input Impedance	True potentiometric; near "infinite" at null. Differential, 500 kΩ nominal. Common mode, 10 MΩ minimum.
Chopper	Field-effect transistors (F.E.T.).
Maximum Input Voltage	±2 volts for differential and common mode.
Chopping Frequency	880 Hz nominal.
Maximum Output Voltage	±12 volts minimum with ±15 volt supply with no load. ±7 volts minimum @ 500 mA.
Maximum Output Current	500 milliamperes average.
Maximum Slewing Rate	200 volts/millisecond with gain of operational amplifier #1 adjusted to 100.
Power Supply Requirements	Driver amplifier: ±15 to 20 volts dc @ 500 mA. All other circuits: ±15 volts dc @ 40 mA. NOTE: The above power may be furnished by a ±15 volt regulated supply capable of 540 milliamperes.

REFERENCE REGULATOR

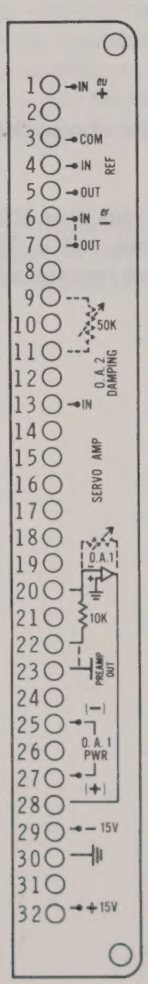
Output Voltage	5.9 to 6.5 volts dc.
Input Voltage	15 volts minimum. 23 volts maximum.
Zener Temperature Coefficient	0.002%/ ° C.
Zener Current	7.5 milliamperes.
Output Current	4 milliamperes, maximum.

DAMPING CIRCUIT

DC Gain	Unity.
Recommended Source Impedance	1000 Ω.

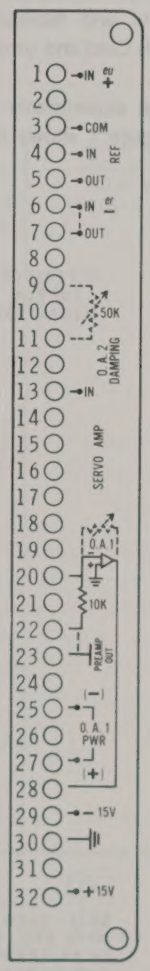
CIRCUIT CONSIDERATIONS

The Servo Amplifier Card is a subsystem of the EU-205-11 Strip Chart Recorder. Because of the unique design, it is possible to use this card for experiments and applications outside the recorder. The following information explains the requirements of the various inputs and outputs of this card and will aid the experimenter to establish the proper external circuit conditions.



CONNECTOR Number	IDENTIFICATION	REQUIREMENT
1	Input to Chopper	This is the non-inverting input when the unit is connected as an operational amplifier. Maximum input voltage is ±2 volts.
3	Reference Supply Common	This is the input and output common of the regulator. It is not the circuit common that is connected to connector number 30.
4	Reference Supply Input	Requires from 15-23 volts dc @ 12 milliamperes.
5	Reference Regulator Output	5.9 to 6.5 volts dc regulated.
6	Input to Chopper	This is the inverting input when the unit is connected as an operational amplifier. Maximum input voltage is ±2 volts.
7	Damping Output	This supplies a signal with a leading phase to the input of the operational amplifier for damping in servo applications. This signal will satisfactorily drive a 2000 Ω load.
9 and 11	Damping Adjust	A 50 kΩ control or a fixed resistor between 0 Ω and 50 kΩ, is required to adjust the amount of damping. It is connected between these two pins.

CONNECTOR Number	IDENTIFICATION	REQUIREMENT
13	Damping Input	Reference from slidewire is normally connected here in servo systems to provide damping. Input impedance is high to prevent loading of the feedback circuits.
20	Inverting Input to Driver Amplifier	Normally a resistor of 2 MΩ or less is connected from this connector to the driver amplifier output (connector 28) to control the gain.
22	Driver Amplifier Signal Input	10 kΩ input impedance.
23	Demodulator Output	The amplified dc level, proportional to the difference between the input signal and the reference, is present here. This output is normally patched to the driver amplifier input, connector number 22.
25	Negative Supply Input	Negative 15 to 20 volts @ 500 milliamperes, supplies the output transistors.
27	Positive Supply Input	Positive 15 to 20 volts @ 500 milliamperes, supplies the output transistors.
28	Driver Amplifier Output	Minimum voltage swing, ±7 volts, @ 500 milliamperes output, maximum.
29	Negative Supply Input	-15 volt supply requires 40 milliamperes.
30	Circuit Common	Common for everything except reference regulator.
32	Positive Supply Input	+15 volt supply requires 40 milliamperes.



OPERATION AND APPLICATIONS

Many interesting and useful experiments can be performed with this Servo Amplifier Card when used with an appropriate power supply and other components. The Analog-Digital Designer (ADD) provides the power requirements and facilitates easy patch-wire connections between this Card and other circuits and devices.

Two typical experiments are shown in this section of the manual. Figure 1 shows the connections for a servo driver such as might be used to control monochromator slit widths, etc. Figure 2 shows the connections for a potentiometric amplifier whose input impedance is near infinite at balance.

Where more than one connection must be made at a point, use a Multiple Connector Card. A Model EU-50-GA Desk-Top Chassis will provide convenient mounting for circuit cards and controls in these experiments.

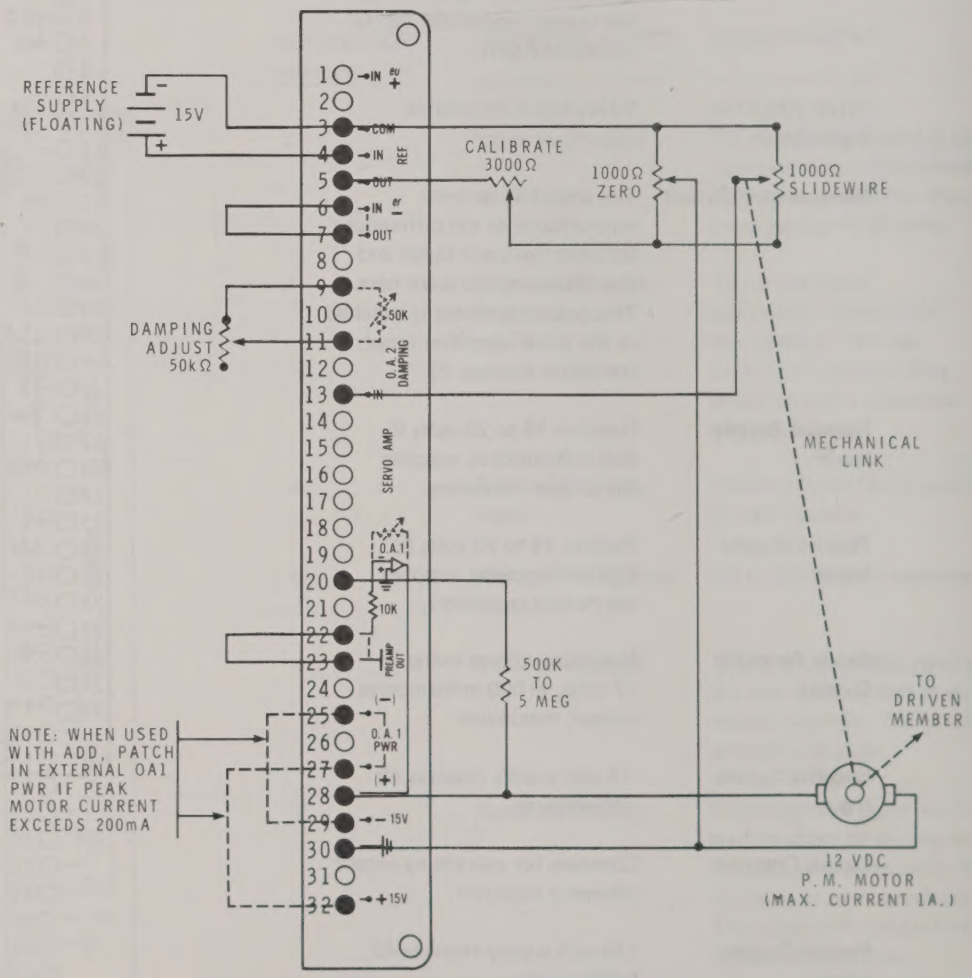


Figure 1 — Connections as a servo driver

When the EU-900-CB Servo Amplifier Card is patched as a potentiometric amplifier (Figure 2) it becomes a non-inverting operational amplifier whose gain is determined by the values of resistors R1 and R2 as follows:

$$\text{Gain} = 1 + \frac{R2}{R1} \quad \text{or} \quad \frac{E_{out}}{E_{in}} = \frac{R1 + R2}{R1}$$

NOTE: Divider (R3 and R4) needed to prevent latch-up by excessive input voltage. Typical values: R1 = 220 Ω, R2 = 22 Ω.

For unity gain, R1 is deleted and connector 1 grounded. R2 must not exceed 50 kΩ.

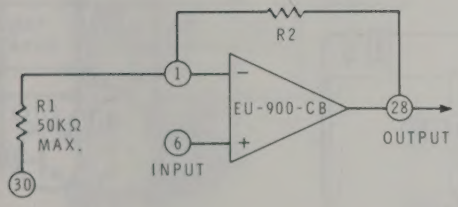


Figure 2A – Circuit for gains higher than ten

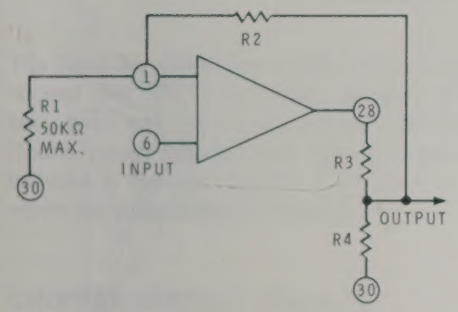


Figure 2B – Circuit for gains of less than ten

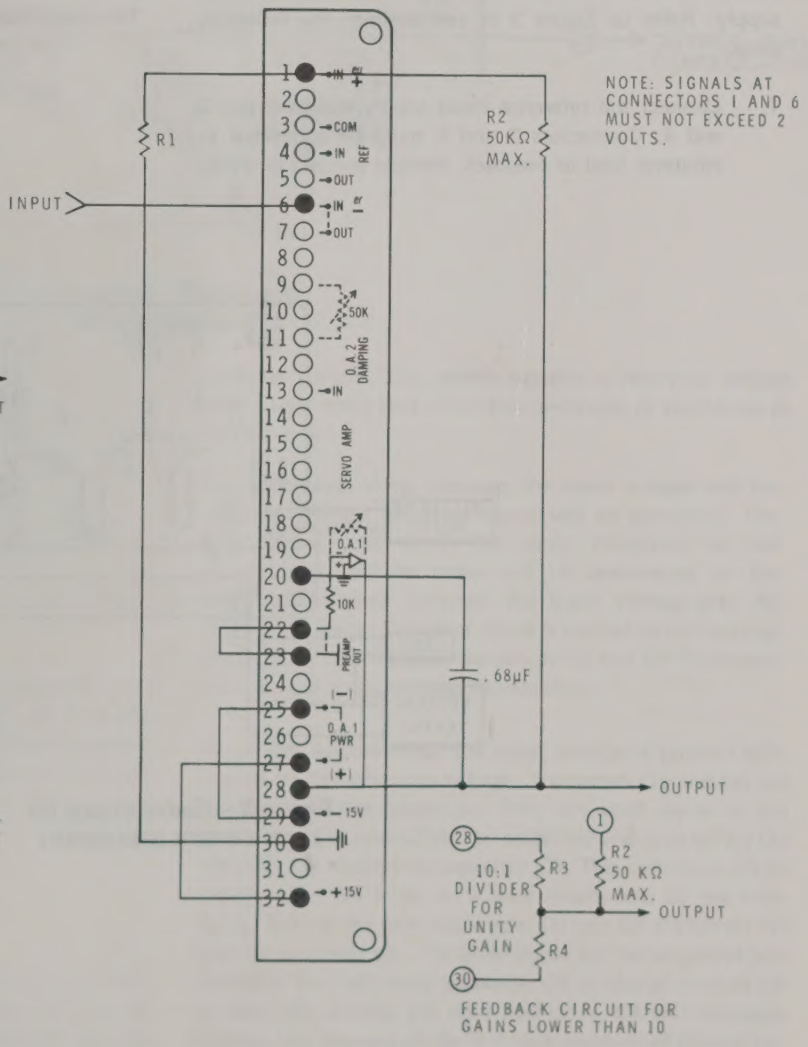


Figure 2 – Connections as a potentiometric amplifier

ADJUSTMENT

The only adjustment on this card is the zener current control, R15, which adjusts the current through ZD2 to its optimum temperature characteristic point. To perform this adjustment you will need a milliampere meter having a maximum input resistance of 1.5 Ω and capable of measuring at least 10 mA and a reference voltage power supply. Refer to Figure 3 as you perform the following steps.

1. Connect the reference input supply to connectors 3 and 4. Connectors 3 and 5 must be connected to whatever load or feedback element you will be using.
2. Unsolder the two wires at TP1 and connect the milliampere meter across them.
3. Adjust R15 for a reading of 7.5 mA, then resolder the wires at TP1.

This completes the adjustment of the Servo Amplifier Card.

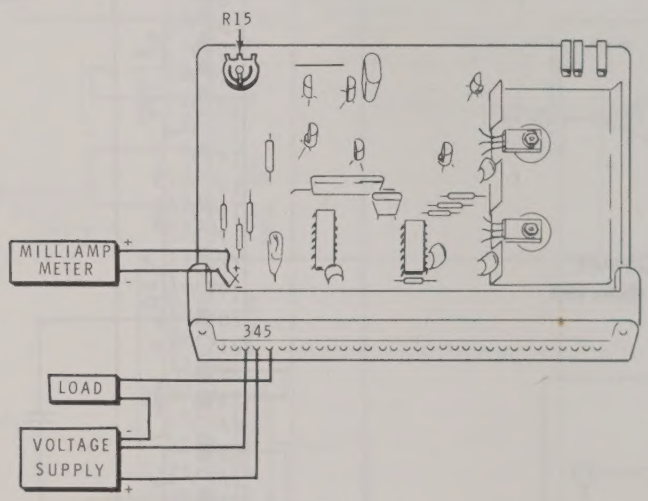


Figure 3 – Connections for zener current adjustment

CIRCUIT DESCRIPTION

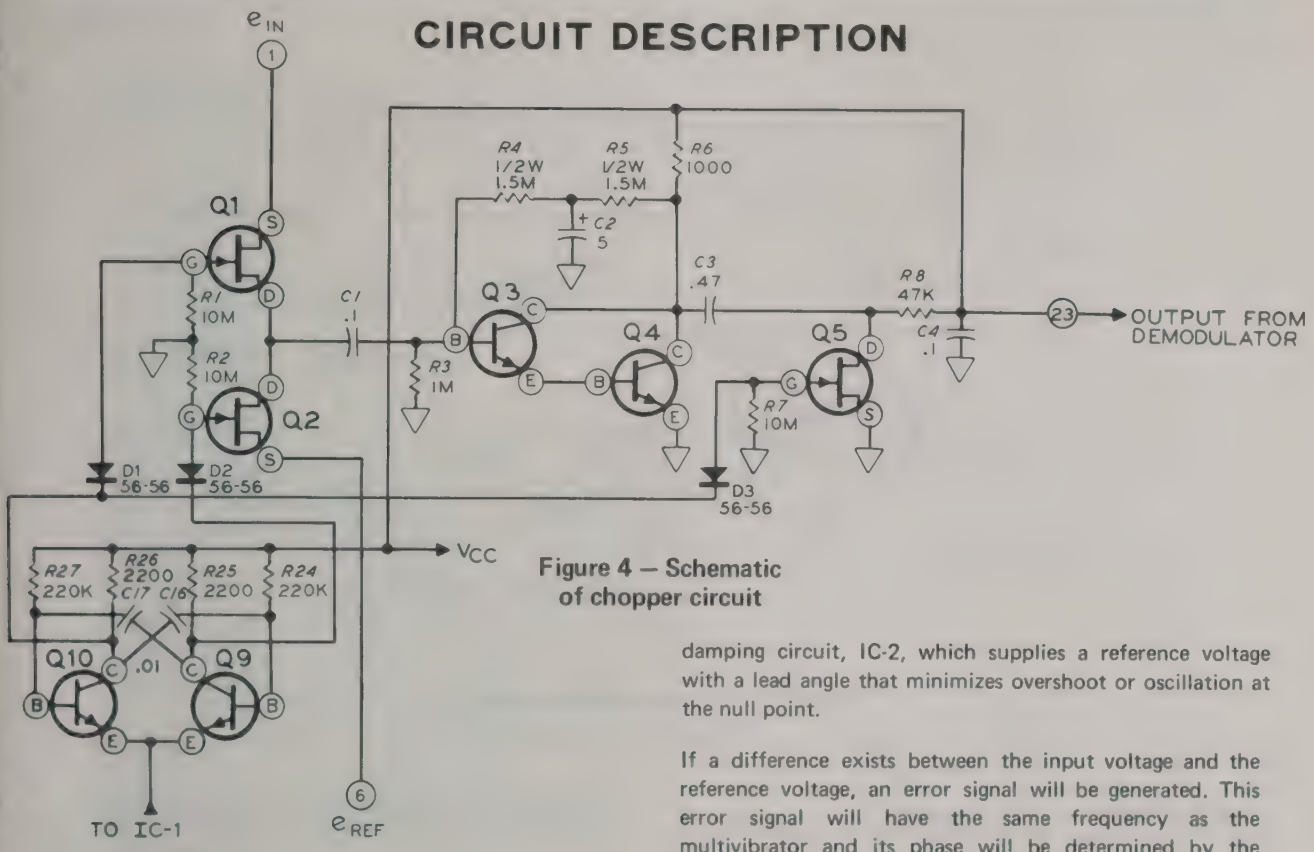


Figure 4 — Schematic of chopper circuit

The Servo Amplifier Card consists of a number of different circuits that will be discussed separately in the following text. While reading this description, refer to the Schematic (fold-out from Page 15), and the circuit schematics that are included in the text. NOTE: This discussion assumes servo motor driver applications of the card.

CHOPPER CIRCUIT (Figure 4)

The chopper circuit consists of two field-effect transistor (FET) switches, Q1 and Q2, which are driven 180° out of phase by a free-running multivibrator. Transistors Q9 and Q10 form the multivibrator that produces two square-wave outputs which swing from +15 volts to −15 volts. These two signals are applied to the gates of Q1 and Q2 through diodes D1 and D2 respectively. These diodes prevent current flow in the gate-source circuits of the FET's.

The voltage to be measured is applied to the source of Q1 and is switched as the FET is turned on and off by the multivibrator. The source of Q2 is connected to the damping circuit, IC-2, which supplies a reference voltage with a lead angle that minimizes overshoot or oscillation at the null point.

If a difference exists between the input voltage and the reference voltage, an error signal will be generated. This error signal will have the same frequency as the multivibrator and its phase will be determined by the polarity difference between the input voltage and the reference voltage. The error signal is applied to an inverting preamplifier consisting of transistors Q3 and Q4. Transistor Q5 is part of a synchronous demodulator.

It will be assumed that the input voltage is positive with respect to the reference voltage. Transistors Q1 and Q5 are switched simultaneously by Q10. An error signal at the junction of Q1 and Q2 will be amplified and inverted by Q3 and Q4, and applied to capacitor C3. This will cause C3 to charge when Q5 is on, to a level determined by the error signal. During the next half-cycle, Q1 and Q5 are turned off and Q2 is turned on. The error signal will be amplified and inverted. This will cause capacitor C4 to charge because Q5 is now off. During the next half-cycle, C4 will discharge slightly but, because of the R-C time constant of R8 and C4, it will be unable to discharge completely. Capacitor C4 will continue to charge on each half-cycle until the input voltage and the reference voltage are equal, or a null point is reached.

The output from the demodulator is taken from the junction of R8 and C4 and is applied to connector number 23. In a typical application this is patched to connector number 22 and applied to driver amplifier IC-1.

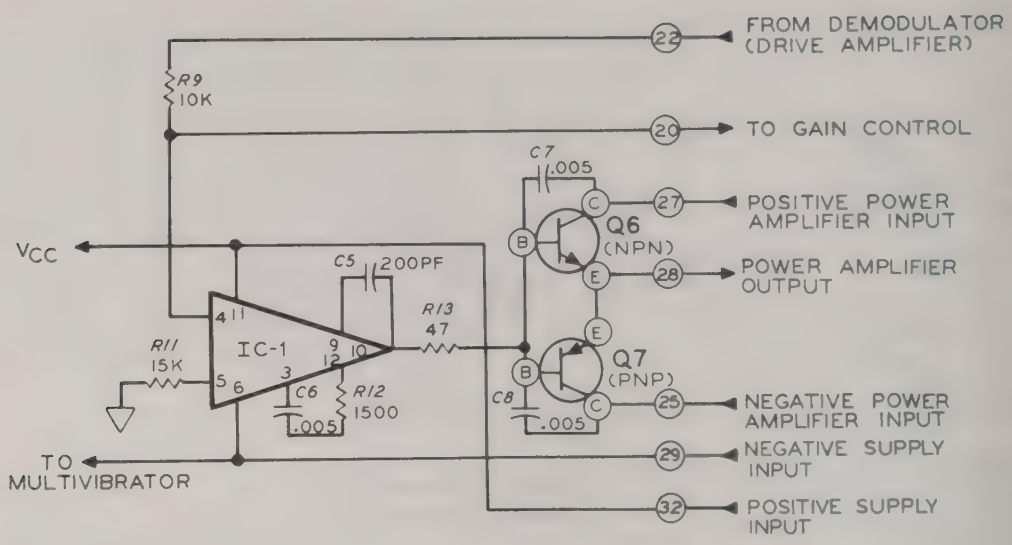


Figure 5 — Driver amplifier circuit

DRIVER AMPLIFIER (Figure 5)

Driver amplifier IC-1 drives the bases of transistors Q6 and Q7, which are complementary emitter followers. The low impedance output from the followers is capable of driving up to 500 mA continuously, in either polarity. In a typical application this output might be used to drive a permanent magnet dc motor or other load.

The gain of the driver amplifier can be adjusted by means of a control connected between connectors 20 and 28 of the circuit card (R408 in the EU-205-11 Strip Chart Recorder). In a typical application, a motor is mechanically connected to a feedback element (slidewire). The direction that the motor will be driven is determined by the polarity of the difference between the input signal and the feedback signal. The direction is always such as to equalize (null) the difference.

DAMPING AND REFERENCE REGULATOR CIRCUITS (Figure 6)

This unity gain amplifier provides a reference voltage with a phase angle that leads the feedback signal to allow the motor to stop at the proper position without overshooting or oscillating. The time constant, or damping of this circuit is adjusted by a control connected between connectors 9 and 11 (R409 in the EU-205-11).

Transistors Q8 and zener diodes ZD1 and ZD2 form a voltage regulator which can be used to provide a regulated voltage for the feedback element. This regulated supply is temperature compensated and double regulated. Transistor Q8 is used as a series regulator with ZD1 used to reference the base. Control R15 allows the current flow through ZD2 to be adjusted to its optimum temperature compensation point (7.5 mA).

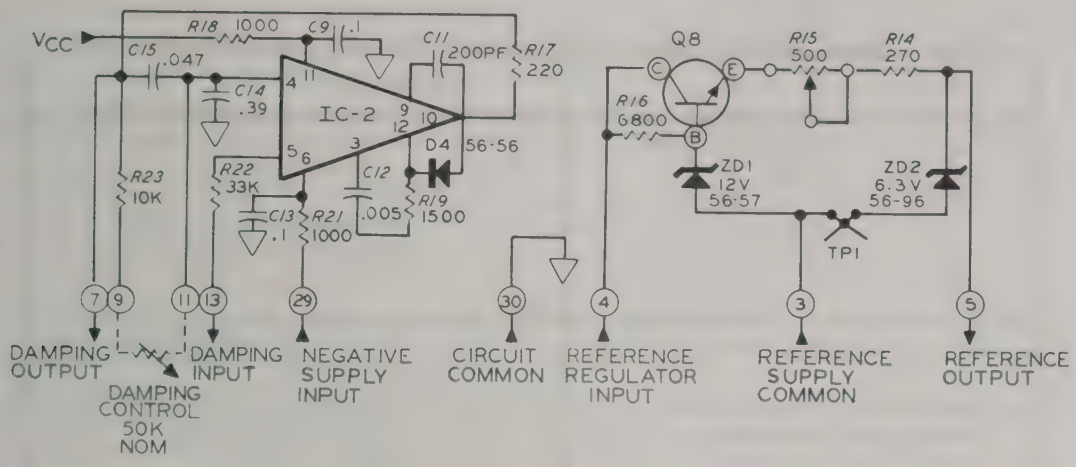


Figure 6 — Damping and reference regulator circuit

IN CASE OF DIFFICULTY

This section of the Manual will help you locate and repair minor difficulties that might arise in the operation of this Circuit Card.

General Troubleshooting describes a basic checkout procedure to identify common problems. The Troubleshooting Chart lists some possible troubles and their probable causes. Circuit Board Repair tells how to replace connectors and components, and how to repair a circuit board foil.

Electronic circuit troubleshooting requires special training and test equipment. If the information in this section of the Manual does not help you locate and repair the problem, do not attempt other repairs unless you have the technical skill and equipment.

GENERAL TROUBLESHOOTING

As the first step, make sure the card is properly seated in the Module or Instrument so the connectors fit snugly on the connector pins. If this card is used in a Module, double check the patch wire connections.

Also check to see that a patch wire fits snugly into each connector. A connector may have become enlarged by inserting a wire larger than #22 or by inserting more than one wire at a time. A connector may also have been damaged by removal or replacement of the connector guide housing.

Visual inspection may reveal a damaged component or a break in the foil. If you find a burned-out part, such as a charred resistor, be sure to locate and correct the cause before you replace the part or put the equipment back into operation.

TROUBLESHOOTING CHART

TROUBLE	POSSIBLE CAUSE
No output from demodulator, signal present at Q9 and Q10.	1. Transistors Q1 through Q5 or associated circuitry. 2. No connection due to incorrect patching or faulty contact of either input #1 or #6.
No output from demodulator or Q9 or Q10.	1. Transistors Q9 or Q10 or associated circuitry.
Damping circuit output stays at one limit with zero input.	1. Damping control incorrectly patched. 2. IC-2 or associated circuitry defective.
Output of operational amplifier #1 stays at one limit with zero input.	1. Feedback resistor not patched between connectors #20 and #28 or faulty contact between feedback resistor and connectors #20 and #28. 2. IC-1 or transistors Q6 or Q7 or associated components defective.
No output from operational amplifier #1.	1. IC-1 defective.
Output from operational amplifier #1 will only go positive from zero.	1. Transistor Q7 defective.
Output from operational amplifier #1 will only go negative from zero.	1. Transistor Q6 defective.
No output from reference supply.	1. Power supply not patched to reference supply input. 2. Transistor Q8, diode ZD1 or ZD2 or associated components defective.
Reference supply drifts.	1. Zener current control R15 incorrectly adjusted. 2. Transistor Q8 or diode ZD1 or ZD2 defective.

CIRCUIT BOARD REPAIR

The correct procedure for replacing integrated circuits, components, and connectors, and for repairing circuit board foils, is presented in the following paragraphs.

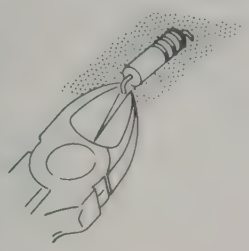
Integrated Circuits

Integrated circuits can be removed by first melting the solder at one pin at a time and removing the solder with a solder sipper or wire brush. Straighten each pin and remove the integrated circuit.

When you install a new integrated circuit, position it so its locating mark lines up with the locating mark on the circuit board; be sure all pins fit into the proper holes. Solder the pins quickly to avoid excessive heat. Begin by soldering pins at opposite corners and then pins on alternate sides of the integrated circuit.

Components

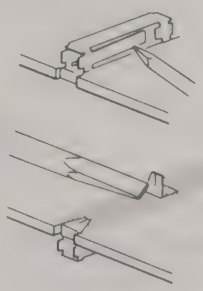
Faulty resistors or capacitors should first be clipped from the circuit board with diagonal cutters as shown. Remove the component leads from the circuit board by heating the solder on the foil side and allowing the lead to fall out of the hole.



Preshape the leads of the replacement part and insert them in the holes in the circuit board; the body of the part should be flush against the board. Then solder the leads to the foil and cut off the excess lead lengths.

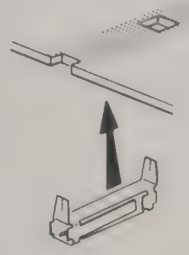
Transistors can be removed in the same manner as resistors or capacitors. The replacement transistor must be installed with its leads in the proper holes; then solder the leads quickly to avoid heat damage. Clip off the excess lead lengths.

Connectors



An enlarged connector can usually be repaired by bending in the spring contacts on its sides. Use a pointed tool as shown. Then test the contact by inserting the end of a #22 patch wire.

To replace a connector, melt and remove the solder from its mounting tabs as shown. Then pry the tabs away from the foil and remove the connector. Install the new connector at the same location with its open end toward the edge of the circuit board. Bend the mounting tabs over and solder them to the foil.



Foil Repair

A break in a circuit board foil can be soldered after first removing the solder-resist coating from the foil in the area of the break. Large gaps in a foil should be bridged with a short length of bare wire. Lay the bare wire across the gap and solder each end to the foil.

NOTE: Refer to Service Information inside the rear cover of this Manual for information on Factory Service, Technical Consultation, Replacement Parts, and Warranty.

REPLACEMENT PARTS LIST

The component designations or the key numbers correspond to the X-Ray View, the Parts Pictorial, or the Schematic.

RESISTORS-CONTROLS (all resistors are 1/4-watt, 10% unless otherwise indicated).

KEY No.	PART No.	DESCRIPTION
R1	1-88-12	10 MΩ
R2	1-88-12	10 MΩ
R3	1-19-12	1 MΩ
R4	1-36	1.5 MΩ, 1/2-watt
R5	1-36	1.5 MΩ, 1/2-watt
R6	1-2-12	1000 Ω
R7	1-88-12	10 MΩ
R8	1-11-12	47 kΩ
R9	1-9-12	10 kΩ
R10		NOT USED
R11	1-10-12	15 kΩ
R12	1-36-12	1500 Ω
R13	1-51-12	47 Ω
R14	1-21-12	270 Ω
R15	10-168	500 Ω control
R16	1-27-12	6800 Ω
R17	1-17-12	220 Ω
R18	1-2-12	1000 Ω
R19	1-36-12	1500 Ω
R20		NOT USED
R21	1-2-12	1000 Ω
R22	1-41-12	33 kΩ
R23	1-9-12	10 kΩ
R24	1-38-12	220 Ω
R25	1-4-12	2200 Ω
R26	1-4-12	2200 Ω
R27	1-38-12	220 Ω

CAPACITORS

KEY No.	PART No.	DESCRIPTION
C1	27-47	.1 μF Mylar*
C2	25-125	5 μF electrolytic
C3	27-61	.47 μF Mylar
C4	27-47	.1 μF Mylar
C5	21-21	200 pF disc
C6	21-46	.005 μF disc
C7	21-46	.005 μF disc
C8	21-46	.005 μF
C9	27-47	.1 μF Mylar
C10		NOT USED
C11	21-21	200 pF disc
C12	21-46	.005 μF disc
C13	27-47	.1 μF Mylar
C14	27-50	.39 μF Mylar
C15	27-73	.047 μF Mylar
C16	27-74	.01 μF Mylar
C17	27-74	.01 μF Mylar

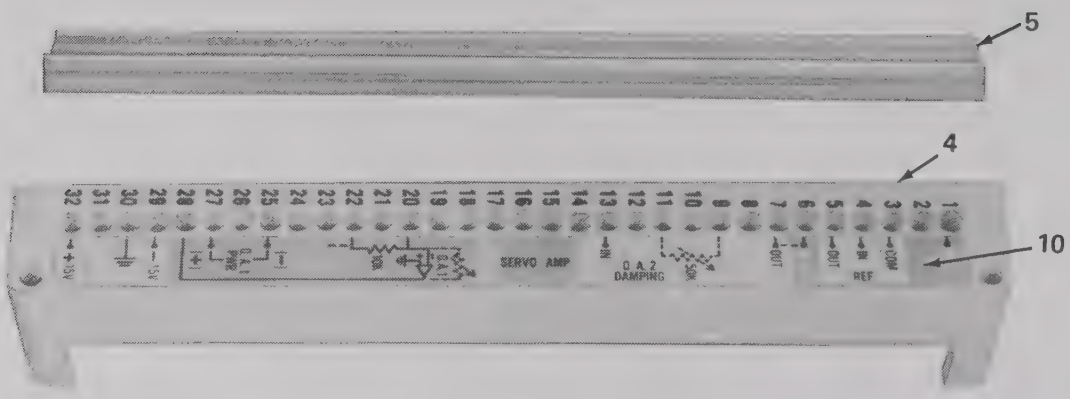
DIODES-TRANSISTORS-INTEGRATED CIRCUITS

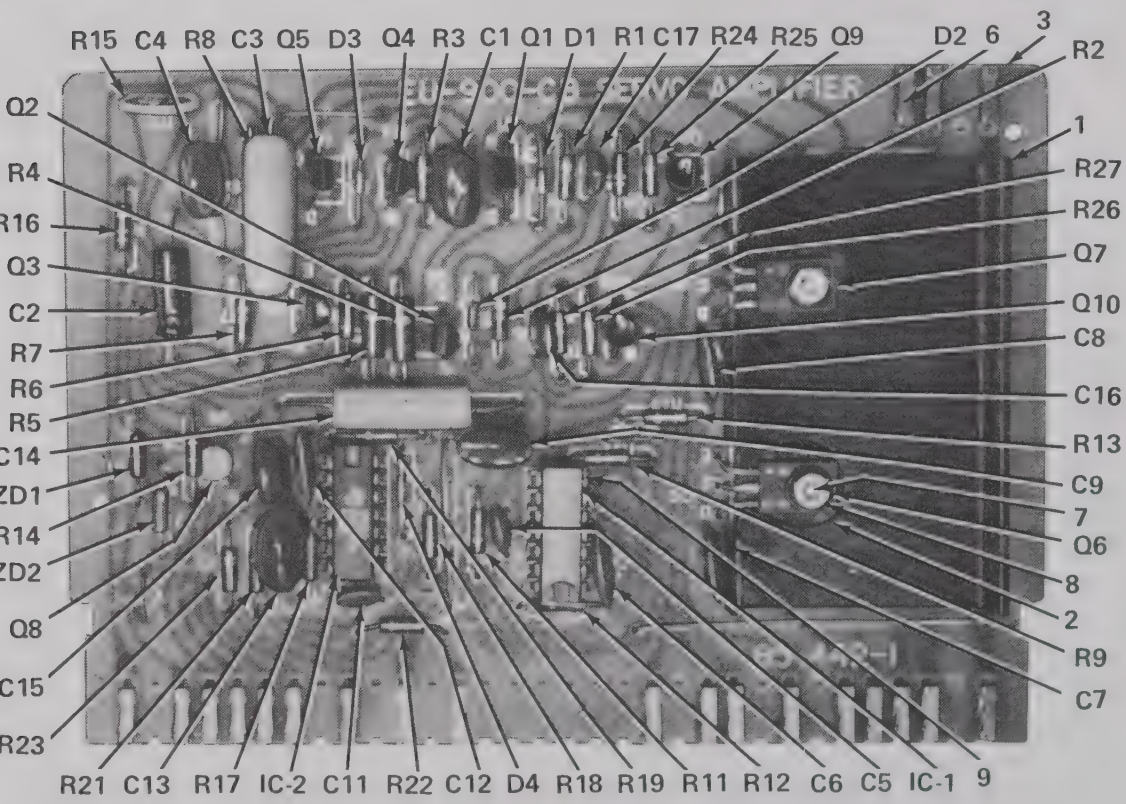
D1	56-56	1N4149 diode
D2	56-56	1N4149 diode
D3	56-56	1N4149 diode

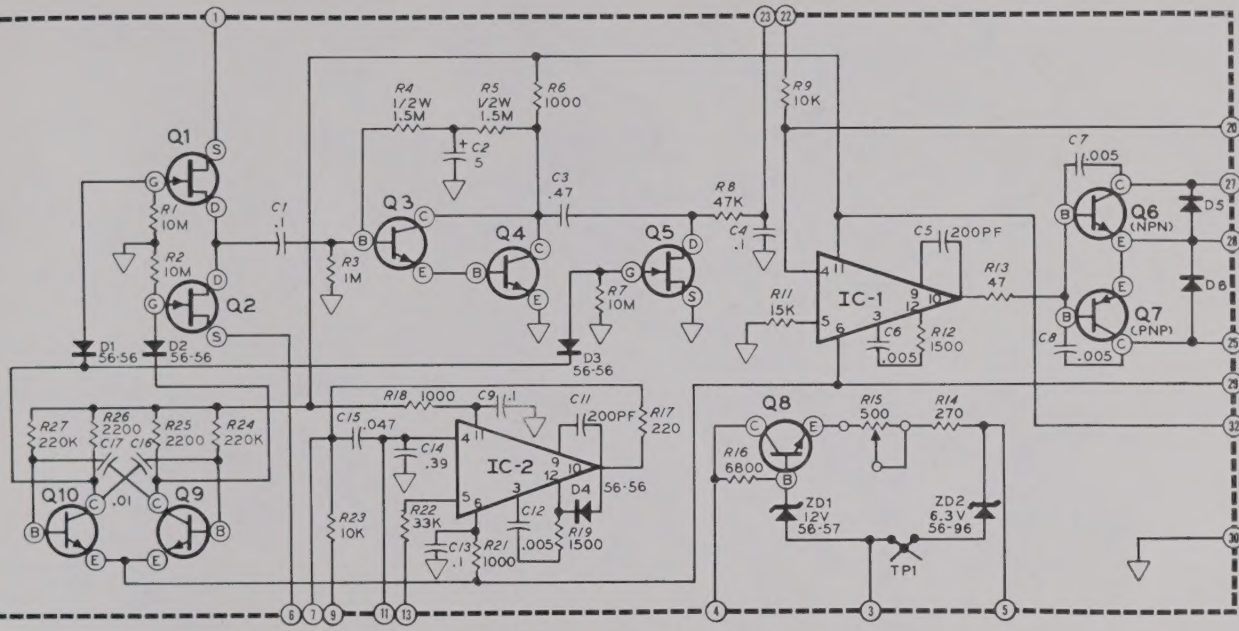
*DuPont Registered Trademark

KEY No.	PART No.	DESCRIPTION
Diodes-Transistors-Integrated Circuits (cont'd.)		
D4	56-56	1N4149
D5	56-56	1N4149
D6	56-56	1N4149
ZD1	56-57	1N716A zener diode
ZD2	56-96	1N825A zener diode (selected)
Q1	417-169	MPF105 transistor
Q2	417-169	MPF105 transistor
Q3	417-118	2N3393 transistor
Q4	417-91	5232A transistor
Q5	417-169	MPF105 transistor
Q6	417-264	SJE608 transistor
Q7	417-263	SJE607 transistor
Q8	417-118	2N3393 transistor
Q9	417-135	2N3859A transistor
Q10	417-135	2N3859A transistor
IC-1	442-2	SN82809 integrated circuit
Diodes-Transistors-Integrated Circuits (cont'd.)		
IC-2	442-2	SN82809 integrated circuit
GENERAL		
1	215-46	Heat sink
2	75-56	Mica insulator
3	85-442-1	Circuit board
4	214-47-1	Connector guide housing
5	333-7	Wire stop
6	432-728	Connector
7	250-172	3-48 x 3/8" screw
8	252-1	3-48 nut
9	432-144	IC connector
10	390-332	Connector guide label
	75-175	Nylon insulator housing

PARTS PICTORIAL

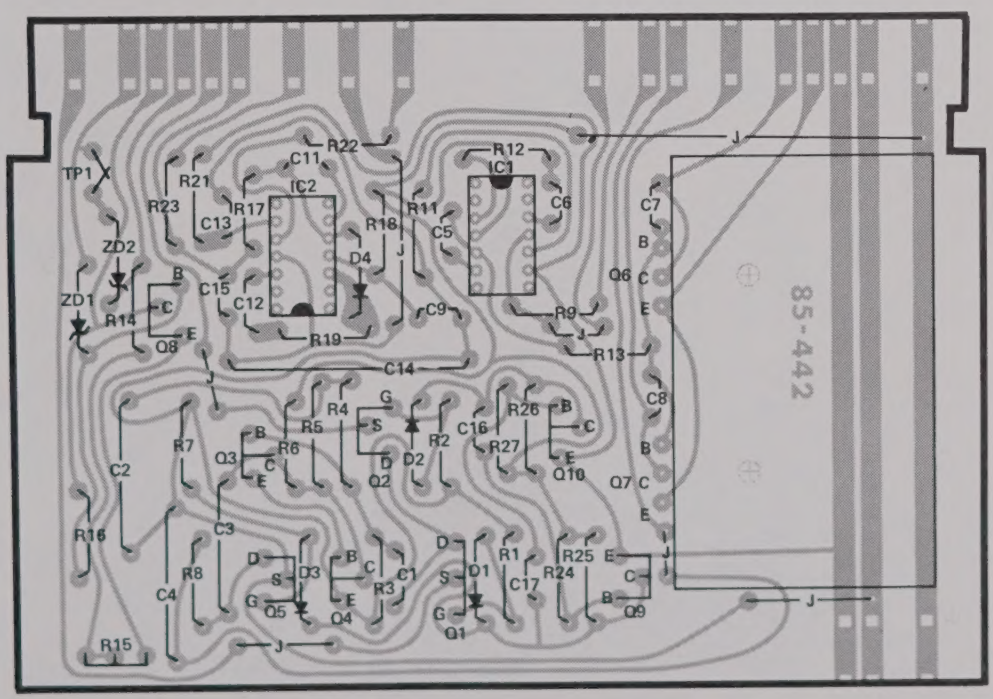






SCHEMATIC OF THE

SERVO AMPLIFIER CARD
MODEL EU-900-CB



(Viewed from foil side)

SERVICE INFORMATION

The following Heath Company services are available if you need them: Replacement Parts, Technical Consultation, and Factory Service. Address all correspondence to:

HEATH COMPANY
Benton Harbor, Michigan 49022

For prompt service, use a separate letter for each department you write to.

Replacement parts and repair service are also available at your nearest Authorized Service Center or Heath Electronic Center. These Centers are listed in your Heath Catalog.

REPLACEMENT PARTS

If a replacement part is needed, please include the following information in your letter:

1. Part number and description.
2. Model Number and Series Number of the equipment.

If your equipment is in the Warranty period, add:

3. Date of purchase.
4. Nature of defect.

Heath Company will fill your order promptly. Please DO NOT RETURN PARTS unless they are requested. Parts that are damaged through carelessness or misuse by the customer will not be replaced without cost.

TECHNICAL CONSULTATION

You can write to our Technical Consultants for help with any Heath equipment, or for answers to any questions about the use of this equipment.

The completeness and accuracy of the advice mailed back to you depends entirely on the information in your letter. Be sure to include:

1. The Model Number and Series Number of the equipment (on blue and white identification label).
2. Date of purchase.
3. An exact description of the difficulty. Include switch positions, connections to other units, operating procedures, voltage reading, and any other information you think might be helpful.
4. List everything you have done in attempting to correct the difficulty.

FACTORY SERVICE

If you do not have qualified repair services at your disposal, you can return your equipment to the Heath Company Service Department to have it repaired for a minimum service fee. (Equipment that has been modified will not be accepted for repair.) Refer to Shipping Instructions for details on how to package and ship the equipment.

To be eligible for replacement parts under the terms of the Warranty, equipment returned for factory service must be accompanied by the invoice or the sales slip, or a copy of either. (If you send the original invoice or sales slip, it will be returned to you.)

SHIPPING INSTRUCTIONS

Check the equipment to see that all parts are in place. Then, wrap the equipment in heavy paper. Place the equipment in a strong carton, and put at least three inches of resilient packing material (shredded paper, excelsior, etc.) on all sides between the equipment and the carton.

Seal the carton with gummed paper tape and tie it with a strong cord. Ship it by prepaid Express or insured Parcel Post to:

HEATH COMPANY
Benton Harbor, Michigan 49022

Attach a letter, containing the following information to the outside of the carton:

1. Your name and return address.
2. Date of purchase.
3. A brief description of the difficulty.
4. Your authorization to ship the repaired unit back to you C.O.D. for the service and shipping charges, plus the cost of parts not covered by the Warranty.

WARRANTY

The Heath Company warrants that under conditions of normal use and service it will repair or replace any factory assembled unit whose performance does not meet published specifications and is returned to Heath prepaid within one year following date of shipment. The published specifications are those labelled "specifications" in the catalog and the manual for the unit. The replacement or repaired unit is shipped prepaid by us anywhere in the continental United States or to APO or FPO addresses. Shipments to other places are FOB factory. Heath's obligation is limited to such replacement or repair by Heath, and Heath is not responsible under this warranty or otherwise for any consequential damage or other loss in connection with the unit or its use.

Questions relating to repairs or warranty replacement in the continental United States (APO and FPO included) should be addressed to Heath Company, attention: Customer Relations, or the nearest Heathkit Electronic Center. In all other areas please contact the authorized Heathkit representative in your country, or Heath Company, attention: International Division.

HEATH COMPANY
Benton Harbor, Michigan 49022

The Heath Company reserves the right to discontinue instruments and to change specifications at any time without incurring any obligation to incorporate new features in instruments previously sold.

MP MASTER
MA22736